EMPHYSEMA: HISTORICAL PERSECTIVE

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IN the preface to the fourth edition of Laënnec's classic treatise on diseases of the chest, the eminent Gabriel Andral stated that medical history is replete with the mistakes of those who ignore the past and accept doctrines without critical examination. This comment is relevant to the recent and belated recognition of emphysema.

The physiologic and clinical concepts of emphysema were developed extensively in the 19th century but the disease had been recognized as a pathologic entity long before. In 1679 Bonet,[1] in the first volume of the *Sepulchretum*, correlated dyspnea and orthopnea with the anatomic finding of lungs distended with air. In 1691 Ruysch,[2] in his *Observationum Anatomico-Chirurgicarum Centuria*, presented illustrations of distended air vesicles under the title, *Vesiculas pulmonalis obstructas;* he thus anticipated the current term, obstructive lung disease, by more than 250 years. In 1710, in volume 2 of *The Pulse Watch*, Floyer[3] proposed "to discover the causes of diseases, and a rational method of curing them by feeling of the pulse." Fortunately he digressed from his subject to observe that "asthma" in man, "broken wind" in horses, and the "crocke" in hawks were all caused by the rupture of distended bladders of air in the lung. The term crocke applied to the peculiar noise made by affected birds during expiration. Floyer pursued his studies on emphysema and, in 1717, published a *Treatise of the Asthma*,[4] which described further the anatomic characteristics of the emphysematous lung and emphasized the incompressibility of the air chambers; this contrasted with the autopsy findings in other pulmonary diseases.

Probably the earliest comprehensive clinical and pathologic report of a case of emphysema was that presented by Watson[5] before the

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Royal Society of London on July 12, 1764, and subsequently published in the *Philosophical Transactions*. The patient was a 28-year-old man who had had chronic shortness of breath and productive cough. He suddenly developed pain in the right chest, became acutely ill, and died in 10 days. Autopsy revealed the lungs to be very greatly distended; in several areas there were large "bladders" filled with air which "no pressure on the surface of the lungs could force back." In the right lung there was a ruptured bleb, partly adherent to the pleura and filled with bloody fluid.

Morgagni[6] in his famous treatise, first published in 1761, described two cases of emphysema. He noted that the air vesicles were distended to the size of filberts and that their shape ranged from globular to oblong. Van Swieten[7] in his discussion of "hydrops" of the lung (1785) noted that this condition may be a complication of emphysema resulting from perforation of distended air cells.

It is now well known that rupture of emphysematous blebs may produce pleural effusion, tension pneumothorax, or subcutaneous emphysema. The latter occurs when the escaping air traverses the interstitial tissues of the lung toward the mediastinum and eventually locates itself under the skin of the neck, face, thorax, or abdomen. The horrendous appearance of the patient prompted Blagden,[8] in 1792, to report a case occurring in a woman who had strained in labor. At the moment of expulsion of the child the patient's face, neck, and upper chest suddenly became very greatly enlarged; on palpation the doctor elicited the "crackling noise which characterises this affection." The subcutaneous emphysema subsided after several weeks. Recovery was attributed to phlebotomy.

Apparently the clinical features of subcutaneous emphysema were known in military medicine as far back as the 16th century. Ambroise Paré was credited by Blagden and others with devising the emergency treatment of inserting a trocar between the ribs in order to permit the escape of air. The physical findings in subcutaneous emphysema are generally similar whether the condition is produced by emphysema of the lungs, by other pulmonary diseases, or by fracture of the ribs. This caused general confusion as to pathogenesis. The subject was not clarified until the early decades of the 19th century.

In 1793 Kellie,[9] a British surgeon, reported the case of a 51-year-old man who had had cough and dyspnea for several years. One night, after

an intense paroxysm of cough, the patient experienced severe pain in the right chest. Within a few days air was present in the subcutaneous tissues from the neck down to the scrotum. When a trocar was inserted into the right chest, a blast of air came through the cannula; this gave the patient great relief and simultaneously blew out a candle. An attempt was made to hold the cannula in place with a cork in the external opening, but this failed. The patient improved after the surgical procedure and survived for a year. Although the findings suggest that the patient had either tuberculosis or lung abscess, the case was reported as one of emphysema, no attempt being made to differentiate between emphysema of the lungs and of the subcutaneous tissues. A clearer picture of emphysema was obtained in Taranget's[10] report (1801), which correlated clinical manifestations of tension pneumothorax and interstitial emphysema with the autopsy findings of emphysematous lungs and ruptured blebs.

Clinical recognition of pulmonary emphysema was established slowly during the first two decades of the 19th century. In 1802 the famous Heberden[11] considered emphysema merely as one of a variety of diseases producing asthma, which he regarded as a specific category that included pneumonia, pleurisy, tuberculosis, and valvular heart disease. In 1808 Badham[12] wrote an extensive essay on the clinical manifestations of bronchitis. He emphasized the obstructive character of the disease and credited Hippocrates, Aretaeus, Aetius, and others with the concept that the disease was primarily bronchial and not parenchymal. Unfortunately part of the concept was that the obstruction was due to viscid tenacious humors generated in the body and carried to the lungs. Badham had little interest in autopsy follow-up but referred to the studies of a colleague, Chevalier, who had noted a striking similarity in a group of cases in which the lungs did not collapse when the thorax was opened.

In 1807 Halliday[13] wrote an extensive article on emphysema. He emphasized its occurrence among military men after thoracic injuries. The article described the clinical, physiologic, and therapeutic aspects of subcutaneous emphysema but scarcely touched upon its relation to pulmonary emphysema. In 1811 Balfour,[14] in reporting a case of subcutaneous emphysema which occurred in a woman in labor, diagnosed perforation of the lung but did not even consider the possibility of an underlying disease.

The dramatic features of subcutaneous emphysema continued to

dominate the literature on emphysema for many years. Breschet's[15] authoritative article in the *Dictionnaire des sciences* (1815) was largely an exposition of the clinical and physiologic facets of subcutaneous emphysema with scant reference to pulmonary emphysema as a predisposing cause.

The first comprehensive American study of emphysema was published in Rees' *Cyclopedia*[16] in 1818. The author quoted liberally from contemporary English writers and, like them, he did not connect the syndrome of subcutaneous air with a pathologic process in the lungs. A similar omission was made by Cloquet,[17] who observed distended air vesicles at autopsy in patients with subcutaneous emphysema but failed to recognize an etiologic relation.

During these years the outstanding contribution to knowledge of emphysema was the anatomical description of the disease by Baillie[18] (1818). Baillie clearly defined the pathologic features such as failure of the lung to collapse when the thorax was opened, dissemination of distended vesicles on the surface, and the occurrence of large spaces of air enclosed by thin membranes of pulmonary tissue. Baillie postulated that the distention of the alveoli was due to trapped air and that the large blebs resulted from the rupture of contiguous alveolar walls.

The year 1819 marked the turning point in the development of our knowledge of emphysema. The occasion was the publication of Laënnec's[19] treatise on mediate auscultation. This work, in addition to clarifying many other pulmonary diseases, introduced for the first time a method for the systematic physical examination of the chest by means of Auenbrugger's percussion and Laënnec's own invention, the stethoscope.

Laënnec presented a complete picture of emphysema. He reported that the lung consisted of lobular aggregations of ovoid or spheroid vesicles filled with air and separated from each other by thin opaque cellular partitions. There were marked variations in the size of the air vesicles, which might be smaller than a millet seed or as large as a cherry stone or haricot. Vesicles of the latter size were produced by the coalescence of adjacent air spaces following rupture of the walls. The clinical manifestations of the disease were cough and dyspnea. The pathognomonic physical signs were resonance on percussion, diminished breath sounds, and sibilant rales. Laënnec made an interesting observation which conforms with the doctrine that we see only that which we

know. He stated that prior to his studies on emphysema he considered the disease uncommon, but since then he had come to recognize that many respiratory afflictions previously diagnosed as asthma were in reality cases of emphysema.

Laënnec considered emphysema to be a complication of bronchial catarrh resulting from valvular obstruction of the very small bronchial tubes. In inspiration the alveolar spaces were filled with air which became trapped and could not be expired through the narrow bronchiolar passages filled with mucus. The course of the disease depended on supervening factors, such as recurrent bronchial infection or physical exertion. Cardiac failure was a frequent terminal event. One unfortunate omission in the first edition of *De l'auscultation médiate* was the failure to clarify completely the relation between pulmonary and subcutaneous emphysema. Laënnec was chided for this by a contemporary, Murat,[20] in the *Dictionnaire de médecine*. In the second edition Laënnec differentiated more clearly between the vesicular and interlobular, or interstitial, manifestations of the disease.

Laënnec's contributions to knowledge of pulmonary diseases were popularized in Great Britain largely through the efforts of John Forbes,[21] who faithfully translated each edition of *De l'auscultation médiate* and added copious editorial comments. In the fourth edition the following footnote appeared: "Vesicular emphysema of the lungs is a much more frequent disease than is commonly imagined. I meet with it constantly in practice. . . ." Forbes was also one of the editors of the *Cyclopedia of Practical Medicine*, which contained an article by Townsend[22] differentiating between traumatic and idiopathic or vesicular emphysema. Townsend's observations, based on more than 100 autopsied cases of emphysema, led him to believe that the larger cavities were not distentions of individual air-cells but were formed by the rupture of adjacent walls; in some cases entire lobules were destroyed.

In 1831 Bouillaud[23] wrote an elaborate article on "Emphysème des poumons"; the title itself suggested that the disease had become established as a clearly defined entity. The author elaborated on Laënnec's studies and contributed interesting observations on the physiologic mechanisms involved in the production of interlobular emphysema.

During this era there were a few publications which helped to confuse the concept of emphysema as a chronic pulmonary disease. In 1829 Piedagnel,[24] writing in the *Journal de physiologie*, stated that his obser-

vations of the emphysematous lung could not be reconciled with the view that dilation of the air spaces preceded extravasation of air into the interlobular tissues. Alderson's[25] studies of subcutaneous emphysema occurring suddenly in children with "hooping cough" also appeared to militate against the doctrine of emphysema as a chronic pathologic process. Even Andral,[26] who edited the 1837 edition of Laënnec's book, decided to classify pulmonary emphysema under the general category of hypertrophy of the lung, which also included compensatory emphysema, a condition of entirely different pathogenesis.

In 1835 Hourmann and Dechambre,[27] pioneers in the study of geriatrics, introduced the concepts of senile emphysema as a normal degenerative process involving the lungs and the osseous structures of the thorax. They had observed that in old age the alveolar walls atrophied, became very thin, and eventually ruptured; this resulted in coalescence of the adjacent air spaces. These changes often were localized and produced no clinical manifestations during the life of the patient. Hourmann and Dechambre also described the formation of large blebs followed by perforation and spontaneous pneumothorax in cases in which there were no pleural adhesions which might prevent collapse of the lung. This contribution was important because it offered a rational explanation for senile emphysema, the cause of which has never been completely understood.

In the preface to one of the translations of Laënnec's book, Forbes commented on the general reluctance of English physicians to adopt physical examination of the chest as a routine diagnostic procedure, partly because of skepticism as to the value of the stethoscope and, chiefly, because the procedure seemed undignified for an English gentleman. This was not the case with William Stokes,[28] who mastered the technique quickly and, in 1836, contributed an important clinical study of emphysema. Stokes had had extensive hospital experience. His essay was devoted almost entirely to the exposition of physical signs under varying conditions of the disease. His descriptions were far more detailed than those of Laënnec and it is possible that he had access to more patients because of the greater prevalence of the disease in Britain.

According to Stokes the physical signs of emphysema were caused by increase of air and lung volume within the thorax, inspiratory elevation of the ribs, downward displacement of the viscera, and coexistence of bronchitis. Stokes noted also that extensive emphysema obstructed

the pulmonary circulation and caused cardiac enlargement. In 1837 Stokes[29] wrote a textbook on diseases of the chest. In the chapter on emphysema he emphasized the relation between bronchitis and emphysema; he considered the former to be "the first link in the chain of morbid reaction." He confirmed Laënnec's contention that dilation of the alveolar spaces was a consequence of bronchial obstruction and he concluded that both the prophylaxis and the treatment of emphysema must rest on the premise that emphysema is the end result of bronchitis. Stokes always gave credit to Laënnec for his great contribution and referred to the disease as "Laënnec's vesicular emphysema." In 1838 Carswell[30] published his classic text on pathologic anatomy which contained remarkably detailed illustrations of emphysematous lungs and further testified to British interest in the disease.

During the same period Louis,[31] the renowned French authority on pulmonary diseases, was also studying the subject. In 1838 he wrote a very extensive essay which was translated by Stewardson, one of his American students, and was published in Philadelphia in the American Medical Library. The approach was chiefly clinical but autopsy findings were also presented. The significant observations included: the variability of the age of onset; the emphasis on cough and dyspnea as the outstanding symptoms; the confirmation of the physical signs of resonance on percussion, diminution of breath sounds, and presence of sibilant rales; and determination of the course of illness, with cardiac failure as a frequent termination. Louis considered emphysema "one of the most frequent and remarkable affections to be found in the whole catalogue of nosology. . . ." The study was based on 92 emphysematous persons whom he had treated within the previous 20 months; there were 42 autopsies. In the treatise mention is also made of a series of 41 cases treated by a colleague, Jackson, within a period of 10 months.

At a meeting of the Royal Medical and Chirurgical Society on December 10, 1839, Budd[32] introduced a new concept in the pathogenesis of emphysema based on the dissection of 20 horses. Budd believed that loss of pulmonary elasticity was a major factor in the dilation of the air spaces and that this might occur in animals and in man on a hereditary basis, without previous manifestations of pulmonary disease. The concept of hereditary influences was revived 125 years later by Laurel and Ericksson[33] in their studies of genetic antitrypsin deficiency in emphysema.

During the first half of the 19th century, physicians in the United States derived most of their information on emphysema from European publications. In 1845 a comprehensive review of the subject appeared in *The Cyclopedia of Practical Medicine*,[34] published in Philadelphia. The author was Townsend, who made many contributions to the British literature. The article reviewed the development of knowledge of emphysema in Europe. Townsend accepted Laënnec's concepts of pathogenesis and acknowledged the etiologic importance of bronchitis. The clinical features, diagnostic physical signs, and anatomic findings were described meticulously, enabling American physicians to gain an improved understanding of the disease. The hazards of recurring attacks of bronchitis in perpetuating the severity of emphysema were also stressed.

Some interesting observations on the pathology of emphysema were made by Hasse[35] in his book on circulatory and respiratory diseases (1846). The author acknowledged the French and English contributions and accepted the relation between bronchitis and emphysema but added that the disease might have other causes. He referred to Louis's study of 53 cholera patients, 23 of whom were found at autopsy to have chronic emphysema. He also mentioned cases of tuberculosis in which the adjacent portions of the lung were emphysematous. Hasse was deeply impressed by the coexistence of emphysema in cases of fibrotic tuberculosis; he postulated that emphysema presented a barrier to the spread of tuberculosis and contributed to the cure of the disease. Hasse described the emphysematous lung most precisely. He noted the dry appearance, the lack of elasticity, the diminution of the capillary bed, the distention of air vesicles, and the rupture of blebs, which permitted air to escape interlobularly or into the pleural cavity.

Although pulmonary diseases were recognized in antiquity, the function of the lungs remained obscure for almost 2,000 years. The subject had intrigued philosophers and scientists but little basic knowledge was gained. The degree of confusion was epitomized by Samuel Pepys. After attending a meeting of Gresham College in which respiration was discussed, he wrote in his diary under the date of January 22, 1665; ". . . it is not to this day known, or concluded on among physicians, nor to be done either, how the action is managed by nature, or for what use it is." Of interest, but irrelevant, was an adjacent entry stating that during the meeting one of the doctors defended the exodus of his fellow

physicians during the plague; he explained that inasmuch as their patients had departed, there was little for the physicians to do.

In 1667 Lower[36] demonstrated experimentally the processes involved in normal breathing but little attention was given to these studies for almost 200 years. The first outstanding publication on respiratory function was made by Hutchinson[37] in 1846; it provided the facts upon which all subsequent studies of pulmonary function have been based. The 114-page thesis described the subdivision of pulmonary volume; although more than a century has passed, only a few changes have been made in this terminology. Hutchinson's instrument for measuring vital capacity was called a spirometer. In order to insure accuracy in his measurements Hutchinson prepared tables based on the height, weight, and age of more than 2,000 subjects. His studies on the diagnosis of disease were limited to tuberculosis but he predicted a wider use of his instrument.

In 1848 the *London Medical Gazette* published two noteworthy articles on emphysema. The first was by Rainey,[38] who described the microscopic anatomy of the disease. Rainey noted the destructive changes in the alveolar capillaries and the replacement of the distended alveolar walls by thin bands of fibrous tissue. The other contribution was by Sibson,[39] who made extensive anatomic studies on hypertrophy and dilatation of the right ventricle resulting from emphysema and on the effects of displacement of the abdominal viscera by the distended lungs.

During this period two American texts on diseases of the chest included informative chapters on emphysema. Gerhard's[40] book, published in Philadelphia in 1850, emphasized the clinical features of the disease. Swett's[41] book, published in New York in 1852, contributed a much more extensive discussion of the pathologic features. It included detailed descriptions of the honeycombed lung, atrophic alveolar walls, destruction of capillaries, and inflammatory lesions of the adjacent small bronchi.

In 1850 Quain[42] devised an instrument called the stethometer, which measured respiratory excursions by means of a string placed around the thorax and attached in front to a graduated dial. The depth of the subject's respiratory movements was reflected in the rotation of an indicator on the dial. The instrument could also be used to compare the expansibility of the two halves of the chest. The inventor hoped that the device would help in the diagnosis of emphysema and other pul-

monary disease but he was very well aware of the device's limitations.

By 1853 emphysema had attained sufficient prominence to become the subject of an international dispute. The chief protagonists were Gairdner,[43] a distinguished British clinician, and Gabriel Andral, the renowned French specialist in pulmonary diseases. Gairdner completely rejected Laënnec's hypothesis that dilatation of the alveolar spaces resulted from inability to emit air through obstructed bronchi. Gairdner also discarded the opinion that degenerative changes in the alveolar walls contributed to the formation of large blebs. Instead, he believed that dilatation of the air vesicles was the mechanical result of inspiration in lungs which were partly collapsed or diseased. Gairdner's article, published in the *British and Foreign Medical Review*, was refuted in the September 1854 issue of the *Archives générales de médicine* by Andral, who not only denied the validity of Gairdner's beliefs but also accused him of plagiarizing from Gallard.[44] The irate Gairdner fumed for two days and then wrote a vitriolic letter[45] to the editor of the *Archives* completely demolishing the concepts of those who took issue with him and documenting his claim to originality.

One of the most impressive German contributions to the subject of emphysema during this period was included in a monograph on respiratory disease by Wintrich,[46] which appeared in 1854. The author investigated many aspects of pulmonary function and devised a spirometer which closely resembled the modern instrument except that the inner component consisted of a large glass bottle instead of the metal cylinder that is now in use. Like his predecessors, Wintrich hoped to gather sufficient data so that the measurements would have diagnostic significance in the detection of emphysema and other pulmonary diseases. In 1857 William Jenner[47] published a knowledgeable article on the etiologic aspects of emphysema. He stressed bronchitis as the primary cause and he contended that partial bronchial obstruction was followed by a chain of physiologic and pathologic processes which resulted in degenerative changes in the pulmonary parenchyma. Jenner attributed the frequent occurrence of the disease in the upper lobes to the greater compressibility of the lower lobes in expiration.

During the decade from 1861 to 1871 many articles on emphysema appeared in the medical literature. Rokitansky[48] and Skoda[49] included discussions of the subject in their classic texts. Schmidtlein[50] and Menjaud[51] worked on the newer concepts of pathologic physiology. Ville-

min[52] described the histologic changes that occur in the alveolar spaces. Greenhow[53] presented a comprehensive picture of the pathogenesis of emphysema caused by bronchitis, differentiating it from senile emphysema. Hensley[54] contributed a detailed critique of the prevailing concepts of the development of emphysema and stressed their inadequacies. He concluded his essay with a comment: if progress seemed slow, it should be remembered that 150 years previously John Floyer had recommended that emphysema be treated by paracentesis of the thorax to permit the external air to "compress the flatulant tumor. . . ."

An outstanding contribution to the pathology of emphysema was made by Lange,[55] who differentiated further between the various types of emphysema found at autopsy and clarified the pathogenesis of the compensatory and senile varieties. Lange's detailed descriptions of the cardiovascular complications of generalized emphysema reflect vast experience. Other writers of this period include Biermer[56] and Bayer,[57] whose studies emphasized the interrelation between anatomic and physiologic factors in the emphysematous lung, and Isaakssohn,[58] who investigated the interalveolar capillaries by dye-injection techniques.

In 1871 a chapter on emphysema appeared in Reynolds' *System of Medicine*. The author was William Jenner,[59] who was by then a recognized authority on the subject and was quoted widely by his contemporaries. The introduction contains the following sentence: "Pulmonary Vesicular Emphysema is a very common, and frequently a grave disease." Jenner made short shrift of the prevailing misconceptions concerning emphysema. He accepted Laënnec's anatomic classification but emphasized that interlobular emphysema, despite its dramatic clinical features, was relatively unimportant and merely resulted from the rupture of a bleb. He stated clearly that subcutaneous emphysema could occur from trauma to a normal lung as well as from chronic pulmonary disease but the pathogenesis was entirely different. He also clarified the origins of the emphysema which occurs in chronic tuberculosis and in the acute respiratory diseases of children.

Jenner's chapter was most comprehensive, covering anatomic, physiologic, and clinical aspects. The description of the emphysematous patient was graphic: "The thorax is barrel shaped; the antero-posterior, lateral, and vertical diameters are increased; the sternum is arched; the lower cervical, dorsal, and upper lumbar spine is curved, concavity forward; the ribs are too horizontal; the intercostal spaces are widened . . . the

costal angle is larger than in health. . . . The shoulders are raised. . . ." The description went on to include every aspect of physical abnormality. Great attention was given to cardiovascular and other complications. Interestingly, Jenner stated that amyloidosis occurring in the course of emphysema was due not to the distention of the air vesicles but to concomitant suppurative bronchial infection.

Jenner ridiculed the current medical and physical treatments; he stated that to be successful it would be necessary to renew the elasticity of the alveolar walls, restore the structures to normal size, repair the apertures in the alveolar walls, and replace the destroyed capillaries. His advice was that bronchitis, the primary disease, be prevented by self-protection against the damp, cold, windy, and foggy English climate.

The extensive work on spirometry by Hutchinson and Wintrich, previously mentioned, inspired the invention of a variety of instruments designed to measure ventilatory function. Most of these devices were soon discarded but two of them were popular for a long time. One was the pneumatometer, introduced by Waldenburg[60] in 1871 for the purpose of determining inspiratory and expiratory pressure. The other was the "Doppelstethograph," invented by Riegel[61] in 1873. This machine recorded respiratory curves and demonstrated the prolongation of expiration in emphysema. The basic idea has survived and is now used in spirometers equipped with timing mechanisms which record the forced expiratory volume.

The first large statistical study of emphysema was published by Lebert[62] in 1874. The material was derived from respiratory disease clinics in Breslau and Zurich and covered the period 1857 to 1874. Of 6,458 cases with respiratory disease in Breslau, there were 764 cases (12%) with emphysema. The proportion of males to females was 9:4. There were 950 sufferers from respiratory disease in the Zurich clinics; 96 (10%) had emphysema, the proportion of males to females being 3:2. The total number of emphysema cases in the survey was 860. The author also quoted data by Biermer showing an annual increase of hospitalized emphysema cases of 1 to 2%; studies made in Prague by Willigk showing a 9.7% increase in autopsy incidence; and Förster's statistics, collected in Würzburg, which showed a 1.3% of emphysema in the period from 1852 to 1859, and a 6% incidence in the period from 1859 to 1863.

In 1876 Marchand[63] contributed a review of emphysema which

produced more confusion than enlightenment but was noteworthy for its bibliography of more than 100 references. Birch-Hirschfeld's[64] article (1877) in his textbook on pathologic anatomy was informative. This author noted the increased recognition of the disease in Germany and correlated the clinical manifestations with the pathologic findings.

Measurements of ventilatory capacity dominated the testing of pulmonary function for many years. Krause's[65] studies were intensive but were concerned chiefly with alterations in vital capacity. In 1883 Pick[66] described his experiences with a variety of instruments. He favored one called the Roth Polygraph, which recorded respiratory movements on a rotating cylinder and made it possible to demonstrate graphically the prolonged expiration characteristic of emphysema. The first significant work on true respiratory function was contributed by Geppert[67] in 1884. His investigations of alveolar gas exchange demonstrated the significance of carbon dioxide retention in emphysema and its relation to respiratory failure. In 1891 Berenstein[68] showed how determinations of the residual air in the lungs could be used as a diagnostic test for emphysema. The basic knowledge for all current testing of pulmonary function was virtually completed by von Basch[69] in 1899 when he introduced instruments for measuring the elasticity, or compliance, of the lungs.

Almost all progress in the knowledge of emphysema was made by British, French, and German investigators. Although there were no outstanding contributions from the United States there was a general awareness of the disease, exemplified by the discourse on physical signs in Austin Flint's[70] manual of auscultation and percussion in 1880. Flint referred to the uniformity of physical findings in a series of cases of emphysema and stressed the characteristic thoracic deformity, respiratory movements, diminished breath sounds, and the percussion note, which Flint named vesiculotympanitic. A lecture by Delafield,[71] professor of pathology and practice of medicine at the College of Physicians and Surgeons, appeared in the *Philadelphia Medical Times* in 1885. Emphysema was one of the subjects covered. The manner of presentation presumed that the audience was familiar with the disease. After citing the history and physical findings, Delafield stated "The diagnosis in this case is, of course, very simple" and proceeded to discuss etiologic considerations and treatment. He also derided the current textbooks for simplifying the pathogenesis.

European investigations of the pathologic anatomy of emphysema continued throughout the 19th century. In 1886 Kläsi[72] made a detailed study of the histology of the emphysematous lung and described the varied cellular changes in the alveolar walls. Grawitz[73] in 1892 made further studies of the histology of emphysema; he noticed how much more readily the disease was being recognized at autopsy. Being a German, he gave credit to Virchow rather than to Laënnec for directing attention to emphysema.

In 1893 Auld[74] emphasized the fibrotic changes in the pulmonary parenchyma. He also described degenerative changes in the nerves of the lung which he thought might facilitate distention of the alveolar spaces. The latter observation was related to experiments by Brown-Séquard[75] in which section of the vagi in animals produced distention of the lungs. In 1899 Hansemann[76] introduced a variety of staining techniques to demonstrate elastic tissue changes and the role of intercommunicating openings between alveolar spaces in the production of emphysema.

During the last decade of the 19th century many treatments for emphysema were popularized; some of these are still in vogue in modified form. The effects of recurrent attacks of bronchitis were well recognized and patients were advised to live in warmer climates during the winter months or, at least, to avoid exposure to dampness, wind, polluted air, and drafts. Expectorants, especially potassium iodide, were prescribed generously, and the benefits and dangers of morphine were well known. The established treatment of right heart failure was digitalis, venesection, and restriction of fluids.

Physical therapy played an important role in the treatment of ambulatory patients. Hydrotherapy and compressed air baths in specially designed pneumatic cabinets were recommended highly by most authorities. The latter treatment was also combined with breathing into rarefied air. Simple respiratory compression exercises were introduced in 1873 by Gerhardt[77] and with the passing of time gradually became more complex. Breathing-chairs were devised which assisted expiration by means of broad straps that pressed against the lower portion of the thorax. Elastic corsets were also introduced to facilitate expiratory movements. Respiratory exercises were given much consideration and were meticulously prescribed to be performed under medical supervision. In 1893 Hughes[78] published a book on respiratory gymnastics for

the instruction of doctors and patients. In many of the larger European cities institutes were established for the treatment of respiratory disease.

In 1890 Steinhoff[79] introduced a therapeutic device for emphysema which looked like an upright piano; within was a pumping mechanism connected to a series of pipes which ultimately led to a tube inserted into the patient's mouth. The purpose was to assist respiration by forcing air into the lungs. This instrument was probably the precursor of recent machines for assisted or controlled respiration. Oxygen was also given by direct inhalation from cylinders filled with the compressed gas, which was inhaled through a mask.

Two treatises published at the close of the 19th century epitomize the development of emphysema. One was an authoritative chapter by Fowler[80] in the book, *Diseases of the Lungs*, published in 1898. The text dealt with pathogenesis, etiology, pathology, clinical manifestations, diagnosis, prognosis, and treatment.

The other publication was a monograph of 113 pages by Hoffmann[81] in Nothnagel's *Encyclopedia of Practical Medicine*. The article was an exhaustive study of emphysema and discussed every facet of the disease from etiology to treatment. The subjects covered included respiratory physiology, pulmonary function tests, gaseous exchange, and even fluoroscopic examination of the chest. The author's familiarity with the subject reflected wide experience. He did not hesitate to ridicule many of the popular treatments. He was also critical of some of the experimental investigations of emphysema which accomplished little and merely served as arguments against vivisection. Hoffmann was adamant in the opinion that emphysema was a disease secondary to bronchitis and that "A true primary emphysema existed only in theory." It is regrettable that his comprehensive study omitted statistical considerations, but this was a failing—or virtue—of most 19th century writers. However Hoffmann mentioned that Charbet, in 1881, in a study of cardiovascular complications of emphysema, had reported on a series of 258 cases.

It is apparent from these writings and others[82] not included in this presentation that emphysema was common in the 19th century and was readily diagnosed by both clinicians and pathologists. In recent decades epidemiologists, on the basis of death certifications, have advanced the opinion that the disease has only recently begun to increase in frequency. According to official government statistics, only 115 emphy-

sema deaths were reported in 1935 in the entire population of the United States. There was a gradual increase in succeeding years and an upsurge in 1950, when 3,157 deaths from emphysema were reported. By 1965 the number had risen to 23,000 and authorities[83, 84] predicted that the number of emphysema deaths might double every five years.

It is difficult to reconcile the prevalence of emphysema in the 19th century with official statistics showing virtual nonexistence of the disease in the early decades of the 20th century. The present review is not concerned with the reasons for this disparity except to point out that the sudden apparent increase of emphysema in the United States may well be an arttifact produced by revision of the *International List of the Causes of Death in 1949* permitting emphysema, for the first time, to be accepted as a primary cause of death. Other factors involved may be the recent increase in availability of pulmonary-function laboratories and therapeutic facilities, the widespread publicity given to emphysema in scientific and popular publications, and the social security compensation for disability from emphysema—which now exceeds $100,000,000 annually. The extensive 19th century literature on emphysema refutes the concept that the disease is a newcomer. The futility of arguing with history has long been recognized.

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